

Adaptive Data Analysis and Processing Technology (ADAPT) for Spacecraft

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Summary Overview

■ Adaptable system

- Prototype reconfigurable processor using FPGA
- Demonstrating platform
- Data processing
- Control systems
- Autonomous correction following SEU
- New configurations

■ Flexibility of software

■ Speed of hardware



Background

- Needs
 - On board data processing
 - Reduced development and operational costs
 - Future missions
- Adaptive computing an essential element
 - Data processing
 - Autonomous operations
 - Optimize operations



Background – Software to FPGAs

- First generation systems
 - General purpose processors
 - Custom circuits and ASICs
- System flexibility associated with software
- Second generation systems and FPGAs
 - Execution speed approaching ASIC
 - Programmability
 - System reconfiguration now possible

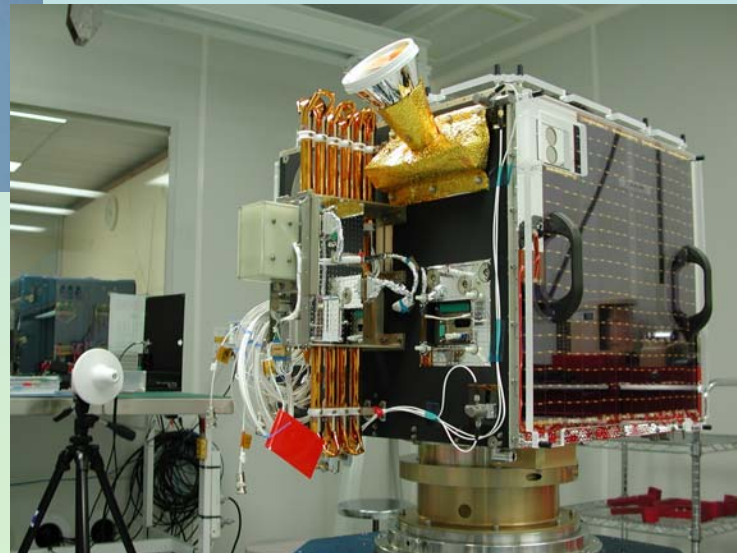
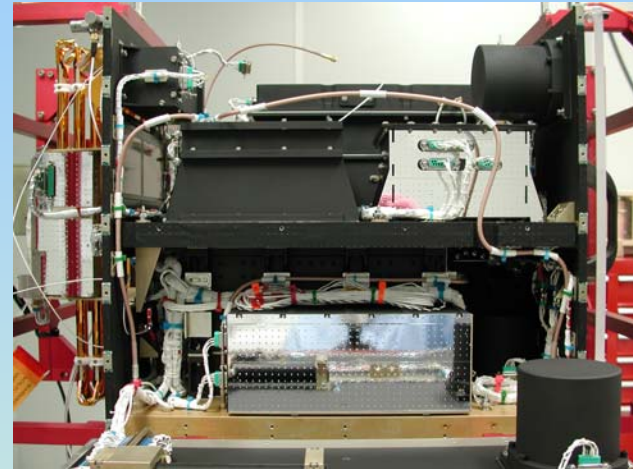


Background – AIM

- Adaptive Instrument Module (AIM)
- Australian FedSat-1
 - Launched December 14, 2002
- Xilinx FPGA
- Configuration and read back verification in software
- Gas and Aerosol Monitoring Sensorcraft (GAMS)
 - LaRC Reconfigurable Data Systems Smart Module



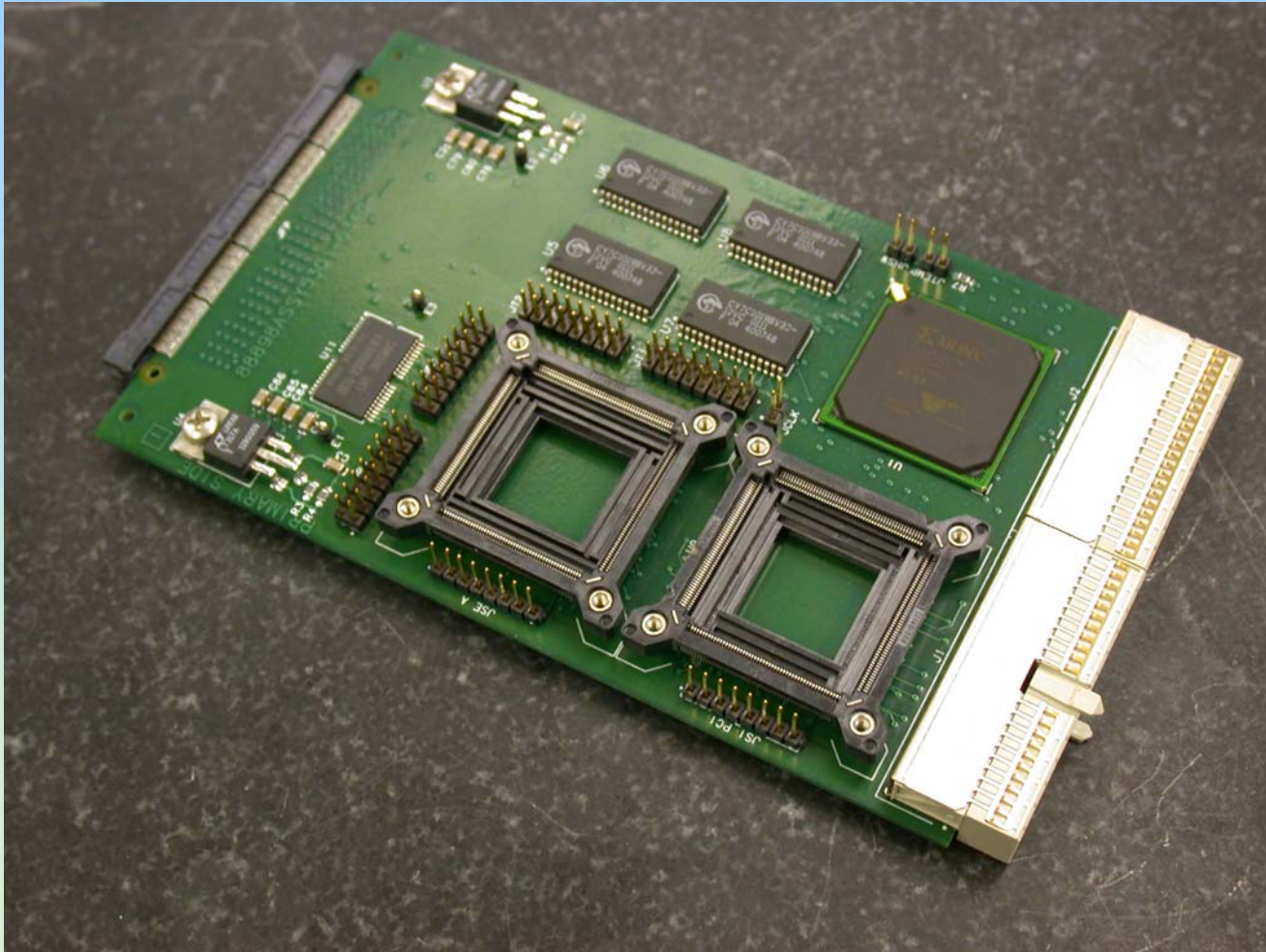
AIM Module and FedSat



Next Generation - ADAPT

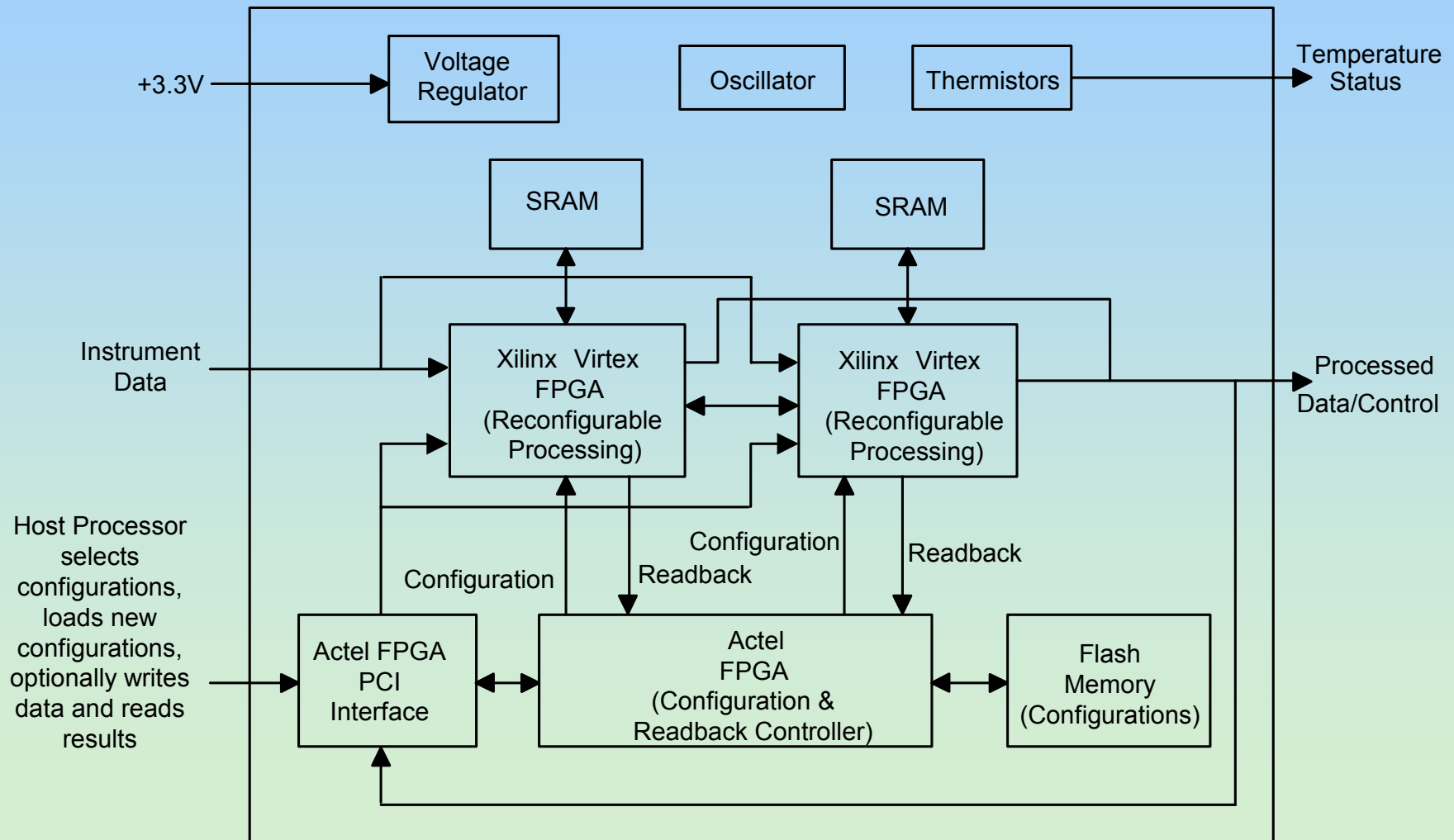


ADAPT





ADAPT Block Diagram





ADAPT Development

- SRAM-based
- Minimize data handling
 - Satellite
 - Ground
- NASA LaRC – instrument design and software
- JHU/APL - hardware



Current Status

- Board fabricated
- Xilinx Virtex II FPGAs verified
 - Read back of configuration files
 - Correction of upsets (e.g. SEUs)
 - Flash programming of configuration stream
- Finishing CompactPCI host and chassis

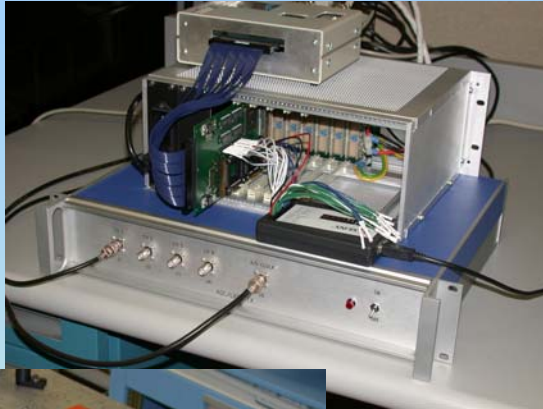


Planned Work

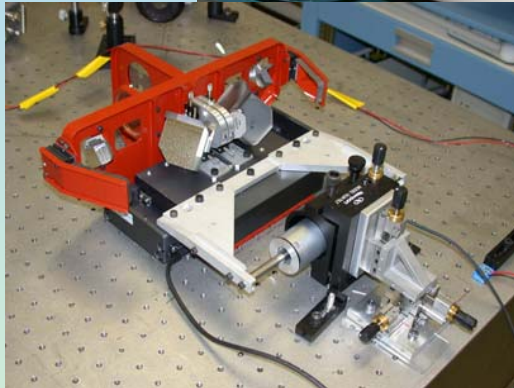
- Final development of PCI interface
- Finish software utilities for programming various tasks
- Radiation test of board
 - Total dose
 - SEU



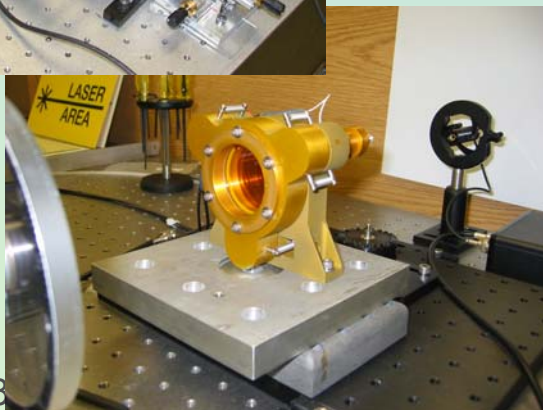
Applications



- Microwave Radiometer: digital correlator processing for up to four I/Q channels



- Fourier Transform Spectrometer (FTS): motion control, based on PID control algorithm, for a linear motor stage



- Fabry-Perot Interferometer: etalon plate displacement control through control of three PZT actuators based on capacitance measurement feedback

ADAPT Novelty and Utility



Summary Points - 1

- Engineering setup for science observations
 - Load configuration file into FPGA
 - Mission only needs to specify file
 - Loading takes about 1 second
 - ADAPT can store about 20 FPGA configurations
- Performance
- Fault tolerance
 - Partial failure remediated by loading a new configuration file that maps around failure
 - Two FPGAs, if one fails completely, use the other



Summary Points - 2

- 17 different I/O standards – flight qualification independent of hardware design
- Testing concurrent with design and programming of FPGAs
- SRAM-based FPGAs
 - Reconfigure in flight
 - Overcome both hardware and software errors



Technical Challenges

- Configuration SRAM susceptible to SEU
 - Check configuration every few seconds
 - Reload correct configuration if needed
- Packaging – 560-pin ceramic grid column array
- Algorithms for self-healing
 - fall back is read-back verification

